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SEMIGRAPHICAL METHOD OF ANALYSING GENETIC VARIATION IN MULBERRY (*Morus* spp.)

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Metroglyph and index score analysis was carried out with 22 Indian and 28 exotic genotypes of mulberry maintained in the germplasm collection of Central Sericultural Research and Training Institute, Mysore. The Indian genotypes fall into three morphological complexes which differed among themselves and exotic genotypes fall into two morphological complexes. Maximum exotic genotypes failed to show better phenotypic performance under Indian environment. Maximum frequency of exotic genotypes occurred around an index score ranging from 1 to 6 and Indian genotypes between 7 to 12. On the other hand, most of the indigenous strains fall into low or medium to low category and the exotic genotypes scored high index value for the component traits influencing moisture content of the leaf. Thus greater morphological, physiological and anatomical variability is observed between exotic and indigenous genotypes among the collections under study.

Key words: Mulberry, *Morus* spp., metroglyph analysis.

The base of the mulberry silk industry depends on the mulberry plants which form the only source of food material for rearing silkworm. As the demand for raw silk has increased world over, sericulture is spreading rapidly in both tropical and temperate countries. More than 21 species of mulberry are known to exist in nature, of which majority remain unexplored (Benchamin *et al.*, 1989). Though the total number of mulberry varieties exceed 1000 (Yokoyama, 1959) hardly 10 per cent of them are being cultivated and the popular varieties form just one per cent. In India, about 560 mulberry genotypes were reported and are being maintained at various Indian Institutes. In Central Sericultural Research and Training Institute, Mysore, a total of 400 accessions are maintained, comprising of 117 exotic, 182 indigenous and 101 elite F_1 hybrids. Various parameters for evaluation of mulberry genotypes for growth

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and yield (Dandin and Kumar, 1989), stress resistance (Susheelamma, 1988), disease resistance (Govindaiah *et al.*, 1989) were reported to screen out suitable ones. The success of genetic improvement in any character depends on the nature of variability present in the gene pool for that character. Hence, an insight into the magnitude of variability present in the genepool of crop species is of utmost importance to a plant breeder for starting a judicious plant breeding programme.

The present paper reports the use of metroglyph analysis in analysing morphological variation in a set of 50 introductions of mulberry (*Morus* spp.). In addition to morphological characters, attempts were also made to examine the association between morpho-physiological and anatomical characters influencing water content and retention ability of the leaf in the genotypes. Water content of excised leaves was proposed as index in screening for stress resistance (Dedio, 1975). Of the total weight of leaf, 50-70 per cent is moisture which determines the nutritive quality of the leaves and play an important role in cocoon quality and quantity (Dandin and Kumar, 1989). As the leaves are stored atleast for 8-10 hours, after harvest till last feeding to silkworm in a day, leaves should retain their moisture content to the maximum without drying. Moisture retention capacity of mulberry leaf is also an important consideration and slow drying is one of the main points to be considered for selection (Kasiviswanathan *et al.*, 1973). There is, thus a need for studying the existance of association, if any, between the morpho-physiological and anatomical characters with a view to build up preliminary selection criteria for picking up desirable types.

Metroglyph analysis (Anderson, 1957) is a semigraphic method for studying variability in a large number of germplasm lines taken at a time. This technique was largely adopted for the assessment of variability in Indian vetiver (Ramanujam *et al.*, 1964), maize (Mukherjee *et al.*, 1971), tobacco (Venkatarao, *et al.*, 1973), green gram (Singh and Chaudhary, 1974), triticale (Kamboj and Man, 1983) and cotton (Singh and Nandheswar, 1983).

MATERIALS AND METHODS

The experimental material comparised 50 genotypes, of which 22 were indigenous and 28 exotic (Table 1). Since it was not possible to study all the Indian and exotic collection, it was decided to select some promising and popular genotypes among the collection being maintained at Central Sericultural Research and Training Institute, Mysore. All the genotypes have been planted in a single row plot under randomised block design with four replications. In each row, 10 competitive plants were randomly selected and tagged for observation. A large number of metric traits were recorded but metroglyph and index score analysis was carried out with only those characters which

Table 1. List of Indian and exotic mulberry genotypes

Sl. No.	Genotype	Origin	Sl.No.	Genotype	Origin
1.	Assamabola	India	26	English Black	France
2.	Ber - C763	-do-	27	Cattaneo	Italy
3.	Ber- C776	-do-	28	Italian Sarnal	-do-
4.	Ber- S1	-do-	29	Ensatakasuka	Japan
5.	Ber- S799	-do-	30	Gosheo-rami	-do-
6.	Bilidevalaya	-do-	31	Ichihei	-do-
7.	Birds foot	-do-	32	Ichinose	-do-
8.	Botatul	-do-	33	Kairyonezymigaeshi	-do-
9.	Chattatul	-do-	34	Kairyoroso	-do-
10.	Cuckpilla	-do-	35	Katania	-do-
11.	Jatinuni	-do-	36	Kenmochi	-do-
12.	Kaliakutai	-do-	37	Kokuso	-do-
13.	Kanva-2	-do-	38	Kokuso-13	-do-
14.	Local	-do-	39	Kosen	-do-
15.	MR-1	-do-	40	Limnocina	-do-
16.	MR-2	-do-	41	Mizusawa	-do-
17.	OPH-3	-do-	42	Rokokuyoso	-do-
18.	S-30	-do-	43	Roso	-do-
19.	S-36	-do-	44	Senmatso	-do-
20.	S-41	-do-	45	Serpentina	-do-
21.	Sujanpur-1	-do-	46	Shin-Ichinose	-do-
22.	Sujanpur-5	-do-	47	Tsukasaguawa	-do-
23.	Moulai	Burma	48	Fernandodias	Paraguay
24.	China Peking	China	49	Chinar	U.S.S.R
25.	China White	China	50	Sanish-5	-do-

were found significant in the analysis of variance. Metroglyph and index score analysis was largely according to the methods suggested by Anderson (1957). The class intervals of the various morphological physiological and anatomical traits are presented in Table 2 and 3. The range in each character has been represented by the different positions of the rays on the glyph. The index scores have been obtained by alloting numerical values to three grades of expression recognised in respect of each character and summing up the scores received by each genotype for all the characters. The analysis was carried out under two conditions, *viz.*, on the morphological traits influencing leaf yield and on morpho-physiological and anatomical characters influencing leaf weight and moisture content of the leaf.

RESULTS AND DISCUSSION

The result of the metroglyph analysis on morphological variation are presented in Fig. 1, where each variety is represented by small circles, the X-coordinate of each circle being number of primary branches per genotype and Y-coordinate, leaf yield per plant (Kg) of each genotype. Six other characters have been represented by rays at different positions on the glyphs.

Table 2. Class intervals and index value for eight morphological traits

Characters	Index Value			
	0		1	2
Leaf yield/plant	< 2.23		2.24-4.0	> 4.1
No. of primary branches	17.2		17.3-30.6	30.7
Length of primary branches	136.1		136.2-214.7	214.8
No. of leaves/m length	21.0	0	22.0-28.0	29.0
Root length	26.0	0	27.0-47.0	48.0
Root to shoot ratio by length	0.9	0	0.91-1.79	1.8
Sprouting %	34.3	0	34.4-66.7	66.8
Rooting %	33.12	0	33.13-64.25	64.26

An examination of the Fig. 1 reveals that nine groups could be recognised. The first group includes 12 varieties, of which 10 are exotic and 2 are indigenous which form low yield with minimum number of primary branches. The second and third group had one exotic variety each, which fall under the category of low leaf yield with medium to more.number of primary branches. Medium leaf yield with less number of primary branches form the fourth group which had 3 indigenous and 6 exotic varieties. The fifth group consist of 6 genotypes, of which 3 are indigenous and 3 are exotic which form medium leaf yield with medium number of primary branches. Group six comprises 4 genotypes, of which 3 are indigenous and 1 exotic. Group seven includes 7 genotypes, of which 1 indigenous and 1 exotic. Group seven includes 7 genotypes, of which 1 indigenous and 6 exotic came under the category of high leaf yield with less number primary branches. Group eight and nine comprised 7 and 3 genotypes, but all are indigenous which have high leaf yield with medium to more number of primary branches.

It could be seen with regard to leaf yield per genotype and number of primary branches, within groups variation was not much.

Among the exotic varieties, the ray pattern in group I, II and III was more or less similar and the index score ranges from 1 to 6. The ray pattern is also similar between group IV and VII and the index score ranges between

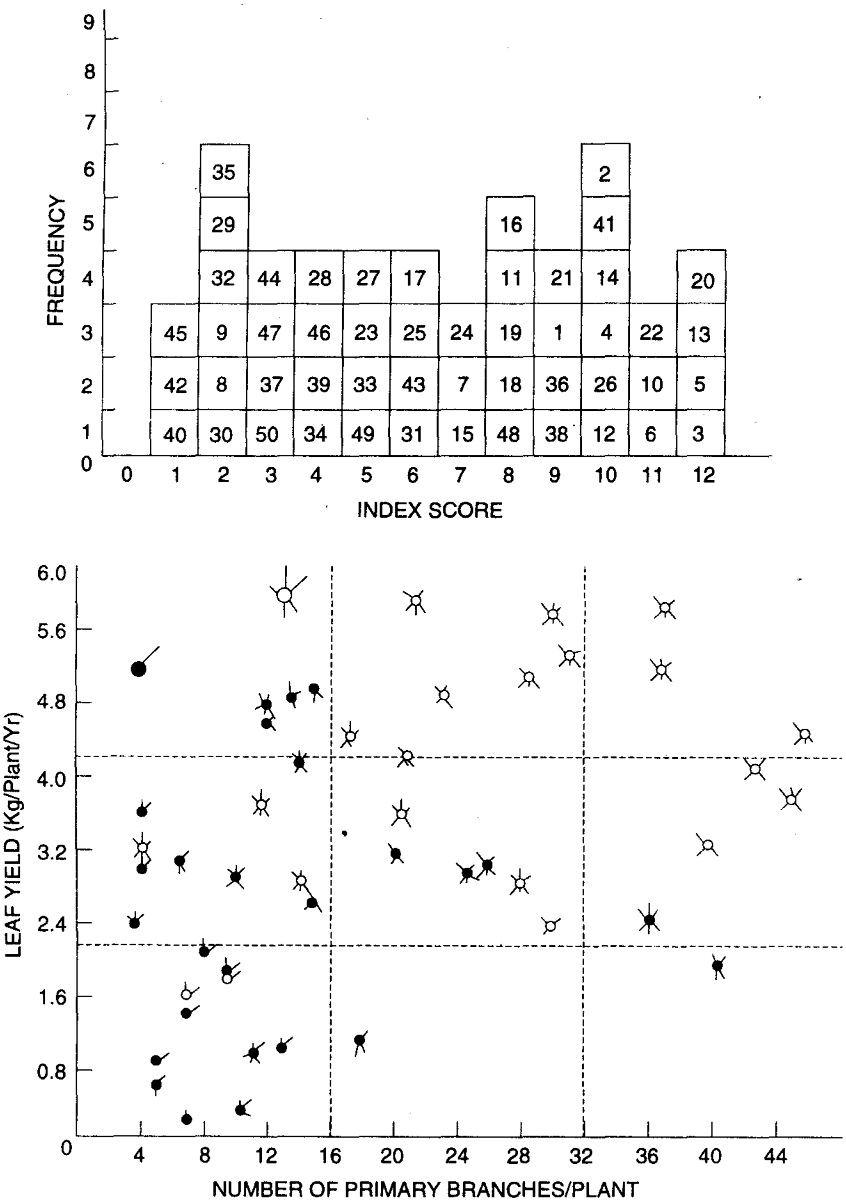

Fig. 1. Scatter diagram of metroglyphs representing morphological characters of 22 Indian (open glyphs) and 28 Exotic (Solid glyphs mulberry genotypes. Inset (top left) Frequency histogram of index scores obtained by the 50 genotypes.

3 to 10. Thus considerable phenotypic variability exist in exotic genotypes between these two morphologically distinct complexes.

No marked differences observed in the ray pattern between group V and VI which comprised 5 exotic and 5 indigenous and the index score ranges between 5 to 11. This indicated that the exotic and indigenous genotypes in group V and VI possess similar morphological variation. The index score ranges between 9 to 12 in group VIII and IX which comprised 10 genotypes and all are indigenous.

It is apparent from the scatter diagram (Fig. 1), that most of the exotic strains fall into low or medium to low yielding groups. Most of them have poor sprouting and rooting. Two primitive genotypes in group 1 appear to be quite different from all the indigenous collection under study. This indicates that these two genotypes fall in the low range for most of the characters. We can tentatively recognize the indigenous genotypes into three complexes on the basis of morphological traits. The group 1 contains two primitive genotypes fall into low yielding one. Group 4, 5, 6 and 7 formed second complex which included 9 genotypes and all came under medium yield. The third complex include group 8 and 9 comprised only indigenous and are high yielding ones.

The result of the metroglyph analysis on character association for increasing moisture content of the leaf are presented in Fig. 2, where each variety is represented by small circle, the X-coordinate of each circle being moisture percentage of the leaf per genotype and Y-coordinate, weight of 100 leaves of each genotype.

Character association analysis revealed that the strains tend to separate out into seven groups (Fig. 2). Most of the indigenous strains fell into low or medium to low weight of 100 leaves as against their moisture content. Maximum frequency of genotypes found around an index score ranging from 5 to 8 (Fig. 1). The variation was not much within and between groups II, III and IV. Maximum number of genotypes found in group V and the index score ranges from 5 to 12 and the variability within the group found strikingly different. Group VI and VII included 15 genotypes, of which, 9 are exotic and 5 are indigenous and the score ranged between 7 to 13. Comparatively the exotic genotypes showed their superiority over indigenous. The exotic genotypes *viz.*, Shin-Ichinose, Kosen, Ichinose, Kokuso, Goshoe-rami and English Black and one indigenous namely Cuckpilla revealed their superiority over others as they scored high index value from 10 to 13.

The problem at hand resolves itself into one of determining whether there exist any morphological complexes among indigenous genotypes and also their relationship with the exotic germplasm currently being maintained in germplasm collection of Central Sericultural Research and Training Institute, Mysore.

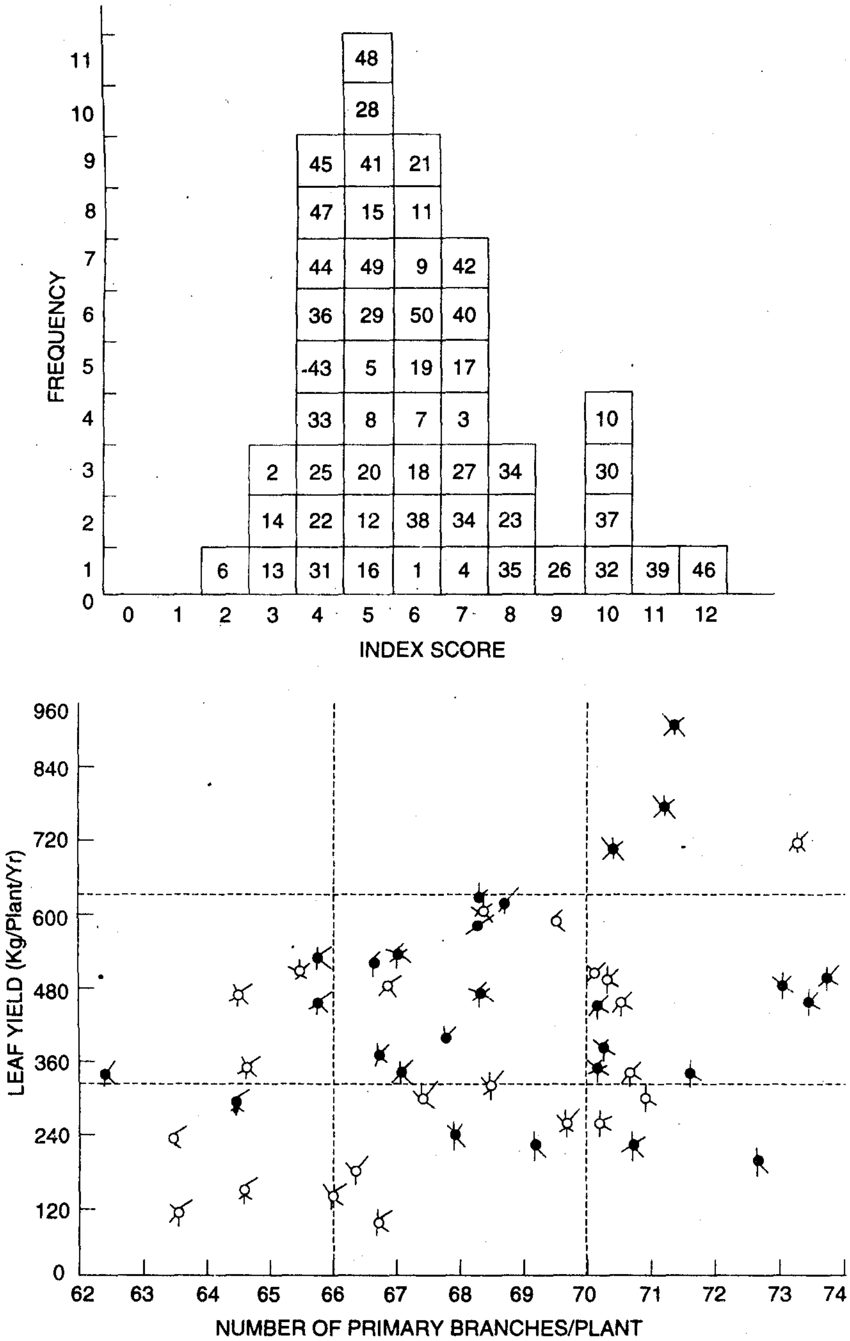

Fig. 2. Scatter diagram of metroglyphs representing morpho-physiological and anatomical characters of leaft of 22 Indian (open glyphs) and 28 Exotic (solid glyphs) mulberry genotypes. Inset (top left) Frequency histogram of index scores obtained by the 50 genotypes.

Table 3. Class intervals and index values for eight morpho-physiological and anatomical traits

Sl. No.	Characters	Index Value		
		0	1	2
1.	Wt. of100 leaves	394 or below	395-651	652 or above
2.	Moisture %	66.04 or below	66.05-69.81	69.82 or above
3.	Leaf area (cm)	138.07 or below	138.08-179.15	179.16 or above
4.	Stomatal frequency/sq.mm	925.27 or above	660-55-925.26	660.54 or below
5.	Ratio of palisade parenchyma to spongy parenchyma	1.18 or below	1.19-1.84	1.85 or above
6.	Moisture retaining capacity (%)	57.74 or below	57.75-63.01	63.02 or above
7.	Cuticle thickness	3.40 or below	3.41-5.32	5.33 or above
8.	Total chlorophyll content (mg/g)	2.282 or below	2.263-3.033	3.034 or above

From the study of metroglyph analysis, the effect of environment on the phenotypic expression of mulberry genotypes could be well conceived. As was pointed out by Anderson (1957), index score indicates the worth of an individual. In the present set of conditions, strains were distributed normally with respect to index score. Maximum frequency of exotic genotypes occured around 1 to 6 and indigenous between 7 to 12. Thus greater phenotypic variability observed between exotic and indigenous genotypes among the collections. Genotypes *viz.*, Kanva-2, Ber-S 799, Ber-C 776 and S 41 had greater variability and revealed their superiority over others as they scored the maximum value.

Many exotic varieties failed to show better phenotypic performance under Indian environment. Exotic varieties introduced from temperate countries and the direct introduction of such genotypes was not successful due to non-adaptability and different environmental conditions (Tazima, 1985). The temperate varieties have a different life cycle pattern, poor rooting, slow and delayed sprouting of buds which render them unsuitable for tropical conditions. However, some of the genotypes *viz.*, Kosen and Goshoe-rami proved successful in Kashmir region owing to the climate parallel with the native countries (Bongale, 1989).

On the other hand, maximum exotic genotypes scored high index value for the component traits influencing moisture content and retention ability of the leaf to increase its feeding value to silkworm. Though the characters are highly influenced by various agronomical practices like spacing, irrigation, soil fertility etc., all the strains have shown their own genetic potential under similar set of conditions. Genotypes possess more leaf area combined with less number of stomata, high ratio of palisade parenchyma to spongy parenchyma, more thickness of cuticle increase moisture percentage and moisture retention capacity of the leaf. This is in confirmation with the earlier findings made by Susheelamma *et al.*, (1989) in mulberry and by Hurd (1968) in wheat cultivars.

Crosses among divergent parents are likely to yield desirable combinations. Therefore, a crossing program should be initiated between the genotypes belonging to different groups. The important points to be considered are (i) choice of the particular group from which genotypes are to be selected as parents and (ii) selection of a particular genotype from the selected group. The present study is a preliminary one and can be further improved by taking more Indian and exotic genotypes and by using sophisticated biometrical techniques of multivariate analysis.

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